System Architecture for High-Speed Transient Diagnostics

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We have applied new system architecture to modernizing a Fabry-Perot (F-P) velocimeter.

There are special needs in terms of channel count, transient record length, dynamic range, and resolution that are specific to the diagnostics for nuclear stockpile measurements. We made a plan to integrate modern large channel-count digital technology with a multi-channel photomultiplier tube (PMT) and a fiber-optic array to supplement or replace the function of an optical streak camera in a specific laboratory application, the F-P velocimeter. For µs record lengths, and ns resolution, modern inexpensive digitizers controlled by fast PCs provide a new alternative that was not available a decade ago.

This type of diagnostic is well-suited to transient diagnosis of fast-moving surfaces driven by explosive forces. Up to now, streak cameras backed with film have been the standard transient recording device for this diagnostic.

Our device will provide up to 100 spatial channels, temporal resolution of 10 ns, and a record length of 10 µs. These 100 channels will record a portion of the overall spatial field that contains all the information necessary to diagnose velocity. Creation of this new device is motivated by cost, durability, and simplicity. Our proposed device will have the footprint of a desktop PC, in addition to a small chassis containing electronics and a PMT.

We focused on a commercial PMT with a linear array of anodes, each coupled to an optical fiber, which are fused together at one end to provide the array input that spans the image plane of the incident light. The PMT outputs are quantized and passed to an array of 100 digitizer channels controlled by a PC. The 100 separate digital records are processed and recombined to produce an image.

Progress in FY02 included system testing to identify the best digital architecture, selection of the appropriate PMT sensor, design and fabrication of the fiber-optic array, and progress toward the design of the discriminator (quantizer) that feeds the digital recording system. A basic schematic of the digital system is shown in Fig. 1.

The fiber-optic array or bundle is used to collect light at the image plane of the F-P interferometer output, and to distribute the light to the separate PMT channels. The plane of the array input corresponds to the normal location of the streak camera input window. The fiber connection gives great flexibility in terms of placing the input arbitrarily with respect to the location of the PMT and the rest of the system. Alignment of the fiber array input end is all that will be required. The completed fiber array is shown in Fig. 2.

The output of the fiber-optic array (Fig. 3) is matched to the spacing of the PMT anodes. The PMT can be placed remotely, and housed in the same chassis as the discriminator electronics.

The key challenge for the continuation of this project is fielding of an integrated instrument, and demonstration that the collected data matches the quality of a streak camera. Our device will hopefully be the first in a continuing line of new diagnostics that fully use modern technology to benefit the LLNL Stockpile Stewardship mission.

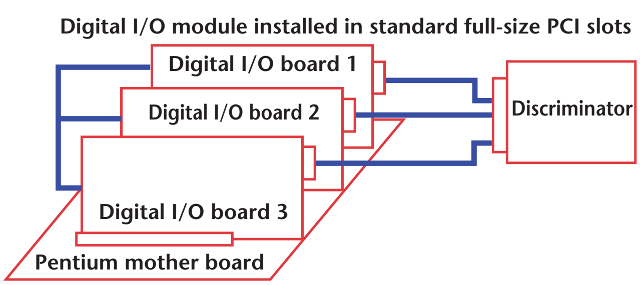

Figure 1. *Digital recording system architecture.*

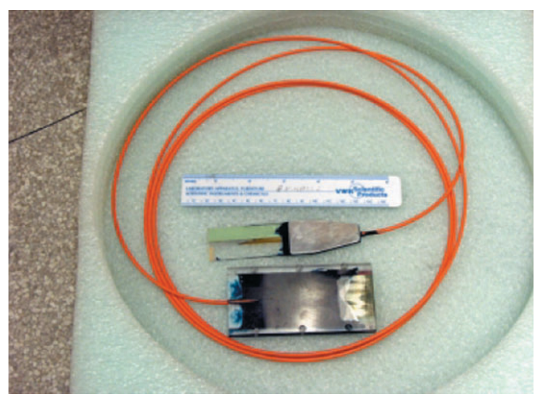

Figure 2. *Completed fiber optic array.*

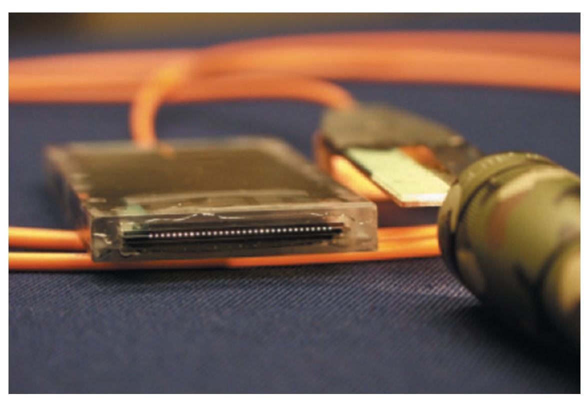

Figure 3. *Fiber optic array output plane.*